6.1 Transfer Functions

1. The equivalent transfer function of three parallel blocks

$$G_1(s) = \frac{1}{s+1}\ ,\ G_2(s) = \frac{1}{s+4} \text{ and } G_3(s) = \frac{s+3}{s+5} \text{ is}$$

(A) $\dfrac{(s^3+10s^2+34s+37)}{(s+1)(s+4)(s+5)}$ (B) $\dfrac{(s+3)}{(s+1)(s+4)(s+5)}$

(C) $\dfrac{-(s^3+10s^2+34s+37)}{(s+1)(s+4)(s+5)}$ (D) $\dfrac{-(s+3)}{(s+1)(s+4)(s+5)}$

2. The block having transfer function

$$G_1(s) = \frac{1}{s+2}\ ,\ G_2(s) = \frac{1}{s+5}\ ,\ G_3(s) = \frac{s+1}{s+3}$$

are cascaded. The equivalent transfer function is

(A) $\dfrac{(s^3+10s^2+37s^2+31)}{(s+2)(s+3)(s+5)}$ (B) $\dfrac{s+1}{(s+2)\,(s+3)\,(s+5)}$

(C) $\dfrac{-(s^3+10s^2+37s^2+31)}{(s+2)(s+3)(s+5)}$ (D) $\dfrac{-(s+1)}{(s+2)(s+3)(s+5)}$

3. For a negative feedback system shown in fig. P.6.1.3

$$G(s) = \frac{s+1}{s(s+2)} \text{ and } H(s) = \frac{s+3}{s+4}$$

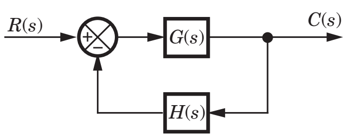


Fig. P.6.1.3

The equivalent transfer function is

(A) $\dfrac{s(s+2)(s+3)}{s^3+7s^2+12s+3}$ (B) $\dfrac{s(s+2)(s+3)}{s^3+5s^2+4s-3}$

(C) $\dfrac{(s+1)(s+4)}{s^3+7s^2+12s+3}$ (D) $\dfrac{(s+1)(s+4)}{s^3+5s^2+4s-3}$

4. A feedback control system is shown in fig. P.6.1.4. The transfer function for this system is

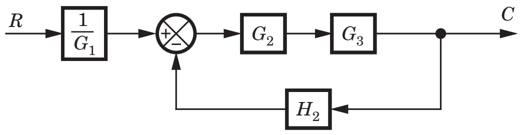


Fig. P.6.1.4

(A) $\dfrac{G_1G_2}{1+H_1G_1G_2G_3}$ (B) $\dfrac{G_2G_3}{G_1(1+H_1G_2G_3)}$

(C) $\dfrac{G_2G_3}{1+H_1G_1G_2G_3}$ (D) $\dfrac{G_2G_3}{G_1(1+H_1G_2G_3)}$

5. Consider the system shown in fig. P.6.1.5.

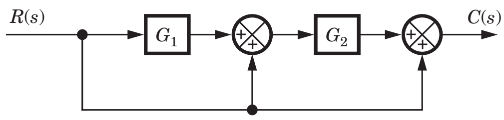
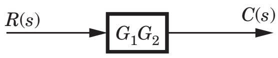
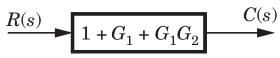


Fig. P.6.1.5

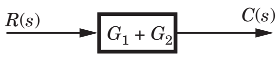
The input output relationship of this system is



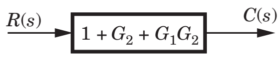
(A)



(B)



(C)



(D)

6. A feedback control system shown in fig. P.6.1.6 is subjected to noise $N(s)$.

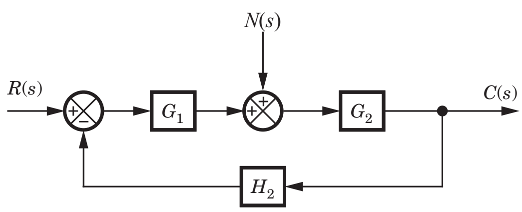


Fig. P.6.1.6

The noise transfer function $\dfrac{C_N(s)}{N(s)}$ is

(A) $\dfrac{G_1G_2}{1+G_1G_2H}$ (B) $\dfrac{G_2}{1+G_1H}$

(C) $\frac{G_2}{1+G_2H}$ (D) None of the above

7. A system is shown in fig. P6.1.7. The transfer function for this system is

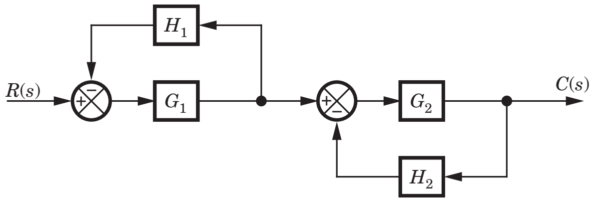


Fig. P.6.1.7

(A) $\frac{G_1G_2}{1+G_1G_1H_2+G_2H_1}$

(B) $\frac{G_1G_2}{1+G_1G_2+H_1H_2}$

(C) $\frac{G_1G_2}{1-G_1H_1-G_2H_2+G_1G_2H_1H_2}$

(D) $\frac{G_1G_2}{1+G_1H_1+G_2H_2+G_1G_2H_1H_2}$

8. The closed loop gain of the system shown in fig. P6.1.8 is

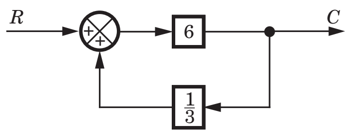


Fig.P6.1.8

(A) –2 (B) 6

(C) –6 (D) 2

9. The block diagrams shown in fig. P.6.1.9 are equivalent if G is equal to

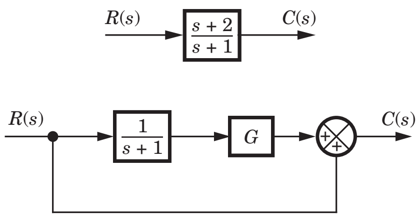


Fig. P.6.1.9

(A) $s+1$ (B) 2

(C) $s+2$ (D) 1

10. Consider the systems shown in fig. P.6.1.10. If the forward path gain is reduced by 10% in each system, then the variation in C_1 and C_2 will be respectively

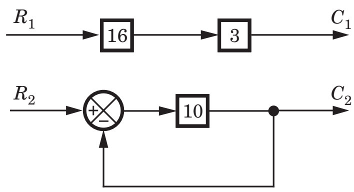


Fig. P.6.1.10

(A) 10% and 1% (B) 2% and 10%

(C) 10% and 0% (D) 5% and 1%

11. The transfer function $\frac{C}{R}$ of the system shown in the fig. P.6.1.11 is

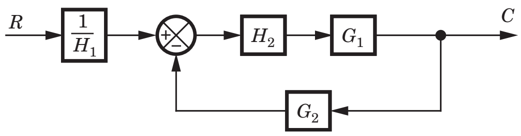


Fig. P.6.1.11

(A) $\frac{G_1H_2}{H_1(1+G_1G_2H_2)}$ (B) $\frac{G_1G_2H_2}{H_1(1+G_1G_2H_2)}$

(C) $\frac{G_2G_1}{1+H_1H_2G_1G_2}$ (D) $\frac{G_1G_2}{H_1(1+G_1G_2H_2)}$

12. In the signal flow graph shown in fig. P6.1.12 the sum of loop gain of non-touching loops is

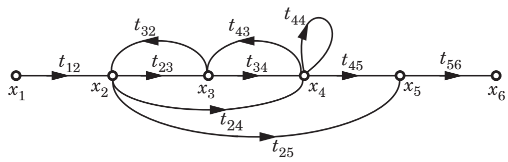


Fig. P.6.1.12

(A) $t_{32}t_{23}+t_{44}$ (B) $t_{23}t_{32}+t_{34}t_{43}$

(C) $t_{24}t_{43}t_{32}+t_{44}$ (D) $t_{23}t_{32}+t_{34}t_{43}+t_{44}$

13. For the SFG shown in fig. P.6.1.14 the graph determinant Δ is

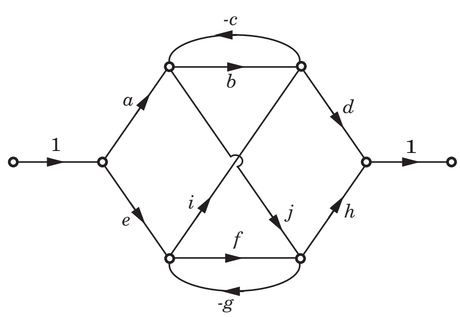


Fig. P.6.1.13

(A) $1-bc-fg-bcfg+cigj$

(B) $1-bc-fg-cigj+bcfg$

(C) $1 + bc + fg + cig\ j - bcfg$

(D) $1 + bc + fg + bcfg - cigj$

14. The sum of the gains of the feedback paths in the signal flow graph shown in fig. P.6.1.13 is

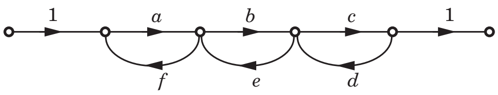


Fig. P.6.1.14

(A) $af + be + cd$

(B) $af + be + cd + abef + bcde$

(C) $af + be + cd + abef + abcdef$

(D) $af + be + cd + cbef + bcde + abcdef$

15. A closed-loop system is shown in fig. P.6.1.15. The noise transfer function $C_n(s)/N(s)$ is approximately

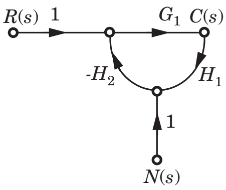


Fig. P.6.1.15

(A) $\dfrac{1}{G_1(s)H_1(s)}$ For $|G_1(s)H_1(s)H_2(s)| << 1$

(B) $\dfrac{1}{-H_1(s)}$ For $|G_1(s)H_1(s)H_2(s)| >> 1$

(C) $\dfrac{1}{H_1(s)H_2(s)}$ For $|G_1(s)H_1(s)H_2(s)| >> 1$

(D) $\dfrac{1}{G_1(s)H_1(s)H_2(s)}$ For $|G_1(s)H_1(s)H_2(s)| << 1$

16. The overall transfer function $\frac{C}{R}$ of the system shown in fig. P.6.1.16 will be

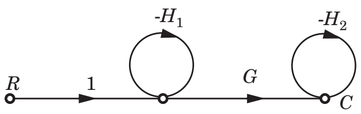


Fig. P.6.1.16

(A) G

(B) $\dfrac{G}{1 + H_2}$

(C) $\dfrac{G}{(1 + H_1)(1 + H_2)}$

(D) $\dfrac{G}{1 + H_1 + H_2}$

17. Consider the signal flow graphs shown in fig. P6.1.17. The transfer 2 is of the graph

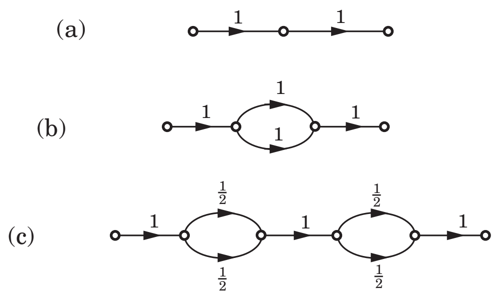


Fig. P.6.1.17

(A) a

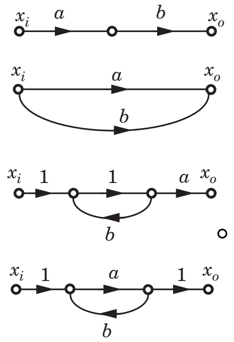
(B) b

(C) b and c

(D) a, b and c

18. Consider the List I and List II

List I (Signal Flow Graph)	List II (Transfer Function)
P.	1. $a + b$
Q.	2. ab
S.	3. $\dfrac{a}{(1 - ab)}$
R.	4. $\dfrac{a}{1 - b}$



The correct match is

	P	Q	R	S
(A)	2	1	3	4
(B)	2	1	4	3
(C)	1	2	4	3
(D)	1	2	3	4

19. For the signal flow graph shown in fig. P6.1.19 an equivalent graph is

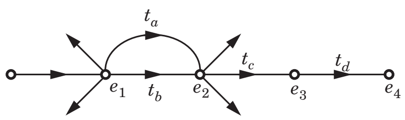
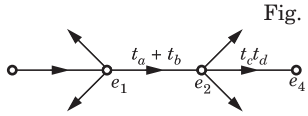
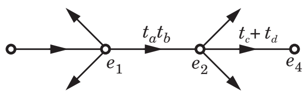


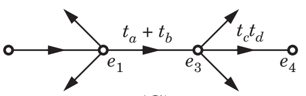
Fig. P.6.1.19



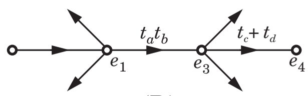
(A)



(B)



(C)



(D)

20. Consider the block diagram shown in figure P.6.1.20

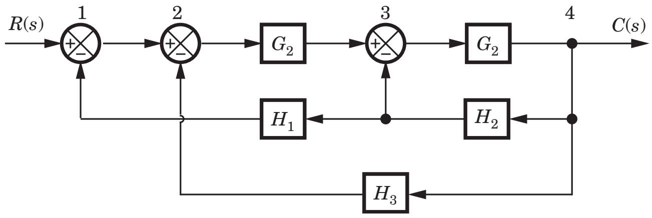
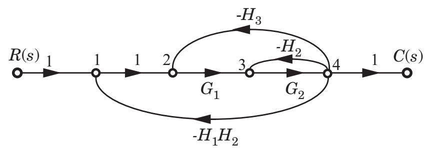
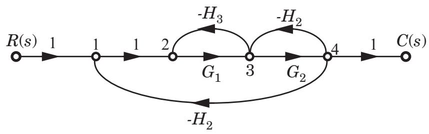
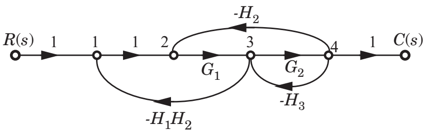


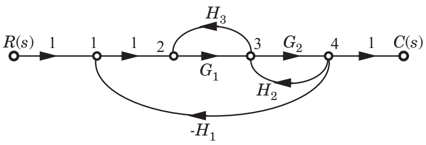
Fig. P.6.1.20

For this system the signal flow graph is

(A) 

(B) 

(C) 

(D) 

21. The block diagram of a system is shown in fig. P.6.1.21. The closed loop transfer function of this system is

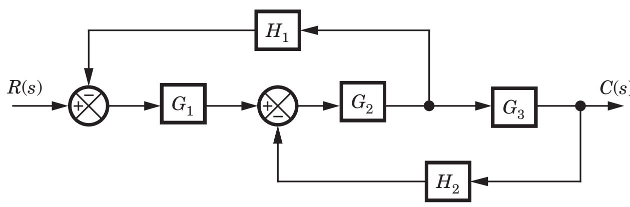


Fig. P.6.1.21

(A) $\dfrac{G_1G_2G_3}{1+G_1G_2G_3H_1}$

(B) $\dfrac{G_1G_2G_3}{1+G_1G_2G_3H_1H_2}$

(C) $\dfrac{G_1G_2G_3}{1+G_1G_2H_1+G_2G_3H_2}$

(D) $\dfrac{G_1G_2G_3}{1+G_1G_2H_1+G_1G_3H_2+G_2G_3H_1}$

22. For the system shown in fig. P6.1.22 transfer function $C(s)/R(s)$ is

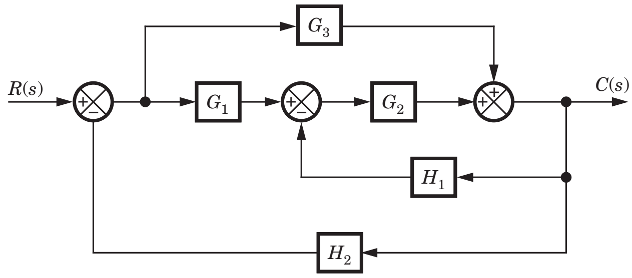


Fig. P.6.1.22

(A) $\dfrac{G_3}{1-H_1G_2-H_2G_3-G_1G_2H_2}$

(B) $\dfrac{G_3+G_1G_2}{1+H_1G_2+H_2G_3+G_1G_2H_2}$

(C) $\dfrac{G_3}{1+H_1G_2+H_2G_3+G_1G_2H_2}$

(D) $\dfrac{G_3}{1-H_1G_2-H_2G_3-G_1G_2H_2}$

23. In the signal flow graph shown in fig. P6.1.23 the transfer function is

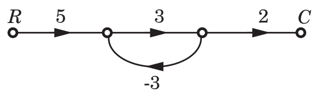


Fig. P.6.1.23

‘

(A) 3.75 (B) –3

(C) 3 (D) –3.75

24. In the signal flow graph shown in fig. P6.1.24 the gain C/R is

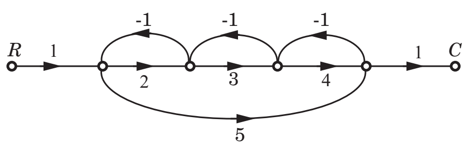


Fig. P.6.1.24

(A) $\dfrac{44}{23}$ (B) $\dfrac{29}{19}$

(C) $\dfrac{44}{19}$ (D) $\dfrac{29}{11}$

25. The gain $C(s)/R(s)$ of the signal flow graph shown in fig. P.6.1.25 is

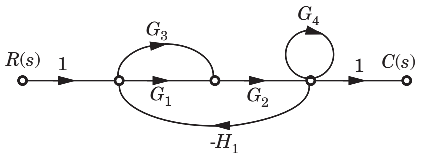


Fig. P.6.1.25

(A) $\dfrac{G_1G_2 + G_2G_3}{1 + G_1G_2H_1 + G_2G_3H_1 + G_4}$

(B) $\dfrac{G_1G_2 + G_2G_3}{1 + G_1G_3H_1 + G_2G_3H_1 - G_4}$

(C) $\dfrac{G_1G_3 + G_2G_3}{1 + G_1G_3H_1 + G_2G_3H_1 - G_4}$

(D) $\dfrac{G_1G_3 + G_2G_3}{1 + G_1G_3H_1 + G_2G_3H_1 + G_4}$

26. The transfer function of the system shown in fig. P.6.1.26 is

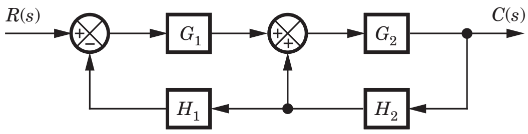


Fig. P.6.1.26

(A) $\dfrac{G_1G_2}{1 - G_1G_2H_1 - G_1G_2H_2}$ (B) $\dfrac{G_1G_2}{1 - G_2H_2 - G_1G_2H_1}$

(C) $\dfrac{G_1G_2}{1 - G_2H_2 + G_1G_2H_1H_2}$ (D) $\dfrac{G_1G_2}{1 - G_1G_2H_1H_2}$

27. For the block diagram shown in fig. P.6.1.27 transfer function $C(s)/R(s)$ is

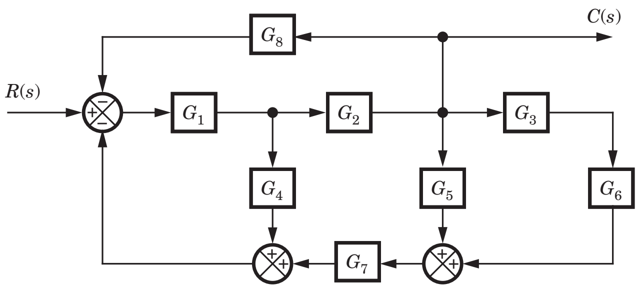


Fig. P.6.1.27

(A) $\dfrac{G_1G_2}{1 + G_1G_2 + G_1G_7G_3 + G_1G_2G_8G_6 + G_1G_2G_3G_7G_5}$

(B) $\dfrac{G_1G_2}{1 + G_1G_4 + G_1G_2G_8 + G_1G_2G_5G_7 + G_1G_2G_3G_6G_7}$

(C) $\dfrac{G_1 + G_2}{1 + G_1G_4 + G_1G_2G_8 + G_1G_2G_5G_7 + G_1G_2G_3G_6G_7}$

(D) $\dfrac{G_1 + G_2}{1 + G_1G_2 + G_3G_6G_7 + G_1G_3G_4G_5 + G_1G_2G_3G_6G_7G_8}$

28. For the block diagram shown in fig. P.6.1.28 the numerator of transfer function is

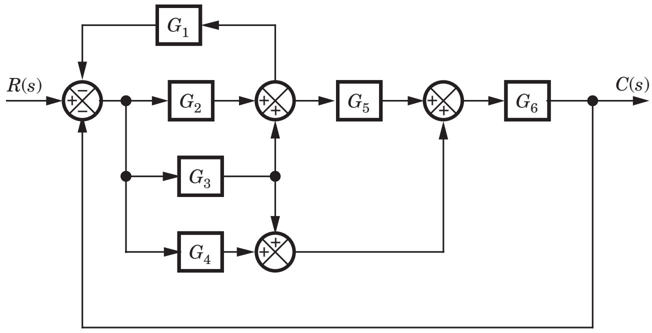


Fig. P.6.1.28

(A) $G_6[G_4 + G_3 + G_5(G_3 + G_2)]$

(B) $G_6[G_2 + G_3 + G_5(G_3 + G_4)]$

(C) $G_6[G_1 + G_2 + G_3(G_4 + G_5)]$

(D) None of the above

29. For the block diagram shown in fig. P.6.1.29 the transfer function $C(s)/R(s)$ is

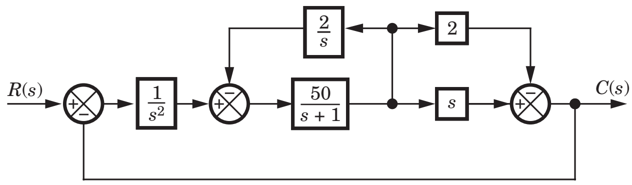


Fig. P.6.1.29

(A) $\dfrac{50(s-2)}{s^3 + s^2 + 150s - 100}$ (B) $\dfrac{50(s-2)}{s^3 + s^2 + 150s}$

(C) $\dfrac{50s}{s^3 + s^2 + 150s - 100}$ (D) $\dfrac{50}{s^2 + s + 150}$

30. For the SFG shown in fig. P.6.1.30 the transfer function $\frac{C}{R}$ is

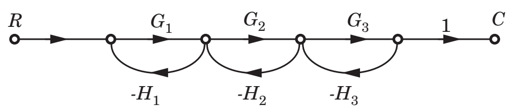


Fig. P.6.1.30

(A) $\dfrac{G_1 + G_2 + G_3}{1 + G_1H_1 + G_2H_2 + G_3H_3}$

(B) $\dfrac{G_1 + G_2 + G_3}{1 + G_1H_1 + G_2H_2 + G_3H_3 + G_1G_3H_1H_3}$

(C) $\dfrac{G_1G_2G_3}{1 + G_1H_1 + G_2H_2 + G_3H_3}$

(D) $\dfrac{G_1G_2G_3}{1+G_1H_1+G_2\ H_2+G_3H_3+G_1G_3H_1H_3}$

31. Consider the SFG shown in fig. P6.1.31. The Δ for this graph is

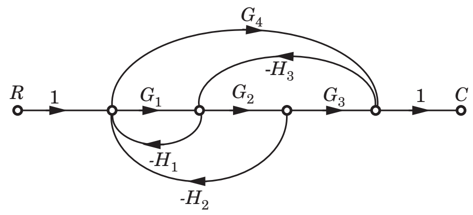


Fig. P.6.1.31

(A) $1+G_1H_1+G_2G_3H_3+G_1G_3H_2$

(B) $1+G_1H_1-G_2G_3H_3-G_1G_3H_3+G_2G_4H_2H_3$

(C) $1+G_1H_1+G_2G_3H_3+G_1G_3H_3-G_2G_4H_2H_3$

(D) $1+G_1H_1+G_2G_3H_3+G_1G_3H_3+G_2G_4H_2H_3$

32. The transfer function of the system shown in fig. P.6.1.32 is

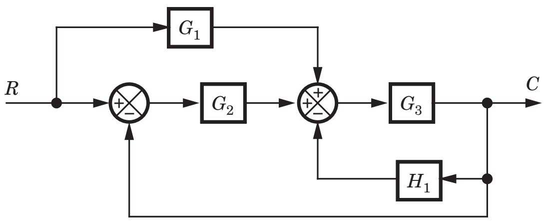


Fig. P.6.1.32

(A) $\dfrac{G_2G_3+G_1G_3}{1-G_3H_1+G_2G_3}$ (B) $\dfrac{G_2G_3+G_1G_3}{1+G_3H_1-G_2G_3}$

(C) $\dfrac{G_2G_3+G_1G_3}{1+G_3H_1+G_2G_3}$ (D) $\dfrac{G_2G_3+G_1G_3}{1-G_3H_1-G_2G_3}$

33. The closed loop transfer function of the system shown in fig. P6.1.33 is

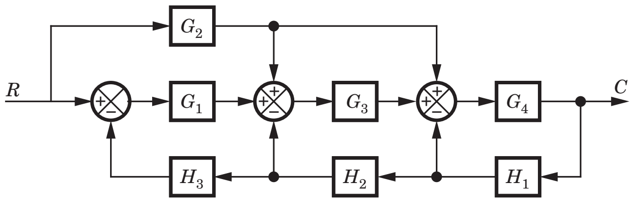


Fig. P.6.1.33

(A) $\dfrac{G_1G_2G_3+G_2G_3G_4+G_1G_4}{1+G_1G_3G_4H_1H_2H_3+G_2H_4H_1H_2+G_4H_1}$

(B) $\dfrac{G_2G_4+G_1G_2G_3}{1+G_1G_3H_1H_2H_3+G_4H_1+G_3G_4H_1H_2}$

(C) $\dfrac{G_1G_3G_4+G_2G_4}{1+G_3G_4H_1H_2+G_4H_1+G_1G_3H_3H_2}$

(D) $\dfrac{G_1G_3G_4+G_2G_3G_4+G_2G_4}{1+G_1G_3G_4H_1H_2H_3+G_3G_4H_1H_2+G_4H_1}$

Statement for Q.34-37:

A block diagram of feedback control system is shown in fig. P6.1.34-37

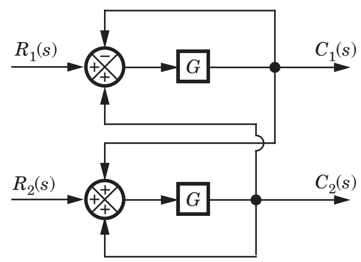


Fig. P.6.1.34-37

34. The transfer function $\left.\dfrac{C_1}{R_1}\right|_{R_2=0}$ is

(A) $\dfrac{G}{1-2G^2}$ (B) $\dfrac{G(1-G)}{1-2G^2}$

(C) $\dfrac{G(1-2G)}{1-G^2}$ (D) $\dfrac{G}{1-G^2}$

35. The transfer function $\left.\dfrac{C_1}{R_2}\right|_{R_1=0}$ is

(A) $\dfrac{G}{1-2G^2}$ (B) $\dfrac{G}{1-G^2}$

(C) $\dfrac{G^2}{1-2G^2}$ (D) $\dfrac{G^2}{1-G^2}$

36. The transfer function $\left.\dfrac{C_2}{R_1}\right|_{R_2=0}$ is

(A) $\dfrac{G\,(1+G)}{1-2G^2}$ (B) $\dfrac{G^2}{1-2G^2}$

(C) $\dfrac{G^2}{1-G^2}$ (D) $\dfrac{G}{1-G^2}$

37. The transfer function $\left.\dfrac{C_2}{R_2}\right|_{R_1=0}$ is

(A) $\dfrac{G(1+G)}{1-2G^2}$ (B) $\dfrac{G}{1-2G^2}$

(C) $\dfrac{G}{1+G}$ (D) $\dfrac{G}{1-G^2}$

Statement for Q.38–39:

A signal flow graph is shown in fig. P.6.1.38–39.

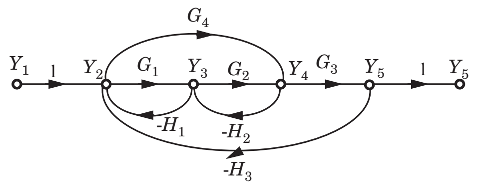


Fig. P.6.1.38-39

38. The transfer function $\frac{Y_2}{Y_1}$ is

(A) $\frac{1}{\Delta}$ (B) $\frac{1+G_2H_2}{\Delta}$

(C) $\frac{G_1G_2G_3}{\Delta}$ (D) None of the above

39. The transfer function $\frac{Y_5}{Y_2}$ is

(A) $\frac{G_1G_2G_3+G_4G_3}{\Delta}$ (B) $G_1G_2G_3+G_4G_3$

(C) $\frac{G_1G_2G_3+G_4G_3}{G_1G_2G_3}$ (D) $\frac{G_1G_2G_3+G_4G_3}{1+G_2H_2}$

Statement for Q.40–41:

A block diagram is shown in fig. P6.1.40–41.

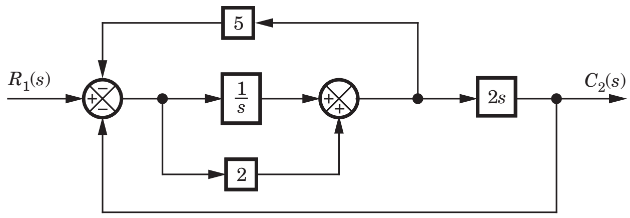


Fig. P.6.1.40-41

40. The transfer function for this system is

(A) $\frac{2s(2s+1)}{2s^2+3s+5}$ (B) $\frac{2s(2s+1)}{2s^2+13s+5}$

(C) $\frac{2s(2s+1)}{4s^2+13s+5}$ (D) $\frac{2s(2s+1)}{4s^2+3s+5}$

41. The pole of this system are

(A) $-0.75 \pm j1.39$ (B) $-0.41, -6.09$

(C) $-0.5, \quad -1.67$ (D) $-0.25 \pm j0.88$

****

Solutions

1. (A) $G_e(s) = G_1(s) + G_2(s) + G_3(s)$

$$= \frac{1}{(s+1)} + \frac{1}{(s+4)} + \frac{s+3}{(s+5)}$$

$$= \frac{s^2+9s+20+s^2+6s+5+s^3+5s^2+4s+3s^2+15s+12}{(s+1)(s+4)(s+5)}$$

$$= \frac{s^3+10s^2+34s+37}{(s+1)(s+4)(s+5)}$$

2. (B) $G_e(s) = G_1(s)G_2(s)G_3(s) = \frac{(s+1)}{(s+2)(s+5)(s+3)}$

3. (C) $\frac{C(s)}{R(s)} = \frac{G(s)}{1+H(s)G(s)}$

$$= \frac{\frac{s+1}{s(s+2)}}{1+\frac{(s+3)}{(s+4)}\frac{(s+1)}{s(s+2)}} = \frac{(s+1)(s+4)}{s^3+7s^2+12s+3}$$

4. (B) Multiply G_2 and G_3 and apply feedback formula and then again multiply with $\frac{1}{G_1}$.

$$T(s) = \frac{G_2G_3}{G_1(1+G_2G_3H_1)}$$

5. (D) $T(s) = G_2(1+G_1) + 1 = 1 + G_1 + G_1G_2$

6. (A) Open-loop gain $= G_2$

Feed back gain $= HG_1$

$$T_N(s) = \frac{G_2}{1+G_1G_2H}$$

7. (D) Apply the feedback formula to both loop and then multiply

$$T(s) = \left(\frac{G_1}{1+G_1H_1}\right)\left(\frac{G_2}{1+G_2H_2}\right)$$

$$= \frac{G_1G_2}{1+G_1H_1+G_2H_2+G_1G_2H_1H_2}$$

8. (C) For positive feedback $\frac{C}{R} = \frac{6}{1-\frac{6\times 1}{3}} = -6$

9. (D) For system (b) closed loop transfer function

$$\frac{G}{s+1} + 1 = \frac{G+s+1}{s+1}$$

$$\frac{G+s+1}{s+1}=\frac{s+2}{s+1}$$

Hence $G=1$

10. (A) In open loop system change will be 10% in C_1 also but in closed loop system change will be less

$C_2=\frac{10}{10+1}=\frac{10}{11}$,

$C'_2=\frac{9}{9+1}=\frac{9}{10}$, C_2 is reduced by 1%.

11. (A) Apply the feedback formula and then multiply by $\frac{1}{H_1}$,

$$\frac{C}{R}=\frac{(H_2G_1)\left(\frac{1}{H_1}\right)}{1+H_2G_1G_2}=\frac{H_2G_1}{H_1(1+G_1G_2H_2)}$$

12. (A) There cannot be common subscript because subscript refers to node number. If subscript is common, that means that node is in both loop.

13. (D) $L_1=-bc,\ L_2=-fg,\ L_3=jgic,\ L_1L_3=bcfg$

$\Delta=1-(-bc-fg+cigj)+bcfg=1+bc+fg-cig\ j+bcfg$

14. (A) In this graph there are three feedback loop. $abef$ is not a feedback path because between path x_2 is a summing node.

15. (B) By putting $R(s)=0$

$P_1=-H_2G_1$, $L_1=-G_1H_2H_1,\ \Delta_1=1$

$T_n(s)=\frac{-H_2G_1}{1+G_1H_2H_1}$

if $|G_1H_2H_1|>>1,\ T_n(s)=\frac{-H_2G_1}{G_1H_2H_1}=\frac{-1}{H_1}$

16. (C) $P_1=G$, $L_1=-H_1$, $L_2=-H_2,\ L_1L_2=H_1H_2$

$\Delta_1=1$

$$T(s)=\frac{G}{1+H_1+H_2+H_1H_2}=\frac{G}{(1+H_1)(1+H_2)}$$

17. (B) $G_a=1,\ G_b=1+1=2,\ G_c=\frac{1}{4}+\frac{1}{4}+\frac{1}{4}+\frac{1}{4}=1$

There are no loop in any graph. So option (B) is correct.

18. (B)

P. $P_1=ab,\ \Delta=1,\quad L=0$, $T=ab$

Q. $P_1=a,\ P_2=b$, $\Delta=1,\quad L=\Delta_k=0,\ T=a+b$

R. $P_1=a,\ L_1=b,\ \Delta=1-b,\ \Delta_1=1,\ T=\frac{a}{a-b}$

S. $P_1=a,\ L_1=ab,\ \Delta=1-ab,\ \Delta_1=1,\ T=\frac{a}{1-ab}$

19. (A) Between e_1 and e_2 , there are two parallel path. Combining them gives t_a+t_b . Between e_2 and e_4 there is a path given by total gain t_ct_d . So remove node e_3 and place gain t_ct_d of the branch e_2e_4 . Hence option (A) is correct.

20. (A) Option (A) is correct. Best method is to check the signal flow graph. In block diagram there is feedback from 4 to 1 of gain $-H_1H_2$. The signal flow graph of option (A) has feedback from 4 to 1 of gain $-H_1H_2$.

21. (C) Consider the block diagram as SFG. There are two feedback loop $-G_1G_2H_1$ and $-G_2G_3H_2$ and one forward path $G_1G_2G_3$. So (D) is correct option.

22. (B) Consider the block diagram as a SFG. Two forward path G_1G_2 and G_3 and three loops

$-G_1G_2H_2$, $-G_2H_1$, $-G_3H_2$.

There are no nontouching loop. So (B) is correct.

23. (C) $P_1=5\times3\times2=30,\ \Delta=1-(3\times-3)=10$

$\Delta_1=1$, $\frac{C}{R}=\frac{30}{10}=3$

24. (A) $P_1=2\times3\times4=24$, $P_2=1\times5\times1=5$

$L_1=-2$, $\quad L_2=-3,\quad L_3=-4,\quad L_4=-5,$

$L_1L_3=8,\ \Delta=1-(-2-3-4-5)+8=23,$

$\Delta_1=1,\ \Delta_2=1-(-3)=4,$

$\frac{C}{R}=\frac{24+5\times4}{24}=\frac{44}{23}$

25. (B) $P_1=G_1G_2$, $\quad P_2=G_3G_2$

$L_1=-G_3G_2H_1$, $\quad L_2=-G_1G_2H_1$, $\quad L_3=G_4$

$\Delta_1=\Delta_2=1$

There are no nontouching loop.

$$T(s)=\frac{P_1\Delta_1+P_2\Delta_2}{1-(L_1+L_2+L_3)}=\frac{G_1G_2+G_2G_3}{1+G_1G_2H_1+G_2G_3H_1-G_4}$$

26. (C) $P_1=G_1G_2$, $L_1=-G_1G_2H_1H_2$, $L_2=G_2H_2$

$$\frac{C(s)}{R(s)} = \frac{G_1G_2}{1 + G_1G_2H_1H_2 - G_2H_2}$$

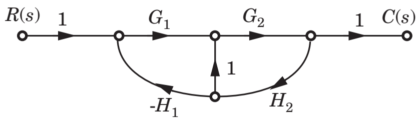


Fig. S6.1.28

27. (B) There is one forward path G_1G_2.

Four loops $-G_1G_4$, $-G_1G_2G_8$, $-G_1G_2G_5G_7$ and $-G_1G_2G_3G_6G_7$. There is no nontouching loop. So (B) is correct.

28. (A) SFG:

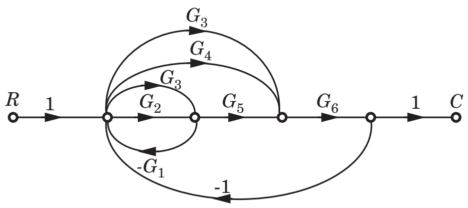


Fig. S6.1.28

$P_1 = G_2G_5G_6$, $P_2 = G_3G_5G_6$, $P_3 = G_3G_6$, $P_4 = G_4G_6$

If any path is deleted, there would not be any loop.

Hence $\Delta_1 = \Delta_2 = \Delta_3 = \Delta_4 = 1$

$$\frac{C}{R} = \frac{G_4G_6 + G_3G_6 + G_3G_5G_6 + G_2G_5G_6}{\Delta}$$

29. (A)

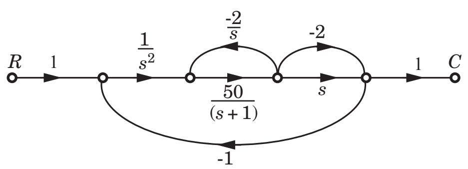


Fig. S6.1.29

$$P_1 = \frac{1}{s^2} \cdot \frac{50}{(s+1)} \cdot s = \frac{50}{s(s+1)}$$

$$P_2 = \frac{1}{s^2} \cdot \frac{50}{s+1} \cdot (-2) = \frac{-100}{s^2(s+1)}$$

$$L_1 = \frac{50}{s+1} \cdot \frac{-2}{s} = \frac{-100}{s(s+1)}$$

$$L_2 = \frac{1}{s^2} \cdot \frac{50}{s+1} \cdot s \cdot (-1) = \frac{-50}{s(s+1)}$$

$$L_3 = \frac{1}{s^2} \cdot \frac{50}{s+1} \cdot (-2) \cdot (-1) = \frac{100}{s^2(s+1)}$$

$$\Delta = 1 + \frac{100}{s(s+1)} + \frac{50}{s(s+1)} - \frac{100}{s^2(s+1)}$$

$\Delta_1 = \Delta_2 = 1$

$$\frac{C}{R} = \frac{P_1 + P_2}{\Delta} = \frac{50(s-2)}{s^3 + s^2 + 150s - 100}$$

30. (D) $P_1 = G_1\ G_2\ G_3$

$L_1 = -G_1H_1,\ L_2 = -G_2H_2,\ L_3 = -G_3H_3$

$L_1L_3 = G_1G_3H_1H_3$

$\Delta = 1 - (-G_1H_1 - G_2H_2 - G_3H_3) + G_1G_3H_1H_3$

$\Delta = 1 + G_1H_1 + G_2H_2 + G_3H_3 + G_1G_3H_1H_3$

$\Delta_1 = 1$

$$\frac{C}{R} = \frac{G_1G_2G_3}{1 + G_1H_! + G_2H_2 + G_3H_3 + G_1G_3H_1H_3}$$

31. (C) $L_1 = -G_1H_1$, $L_2 = -G_2G_3H_3$

$L_3 = -G_1G_2H_2$, $L_4 = G_2G_4H_2H_3$

$\Delta = 1 - (-G_1H_1 - G_2G_3H_3 - G_1G_3H_3 + G_2G_4H_2H_3)$

$= 1 + G_1H_1 + G_2G_3H_3 + G_1G_3H_3 - G_2G_4H_2H_3$

32. (C) $P_1 = G_2G_3$, $P_2 = G_1G_3$,

$L_1 = -G_3H_1$, $L_2 = -G_2H_3$, $\Delta_1 = \Delta_2 = 1$,

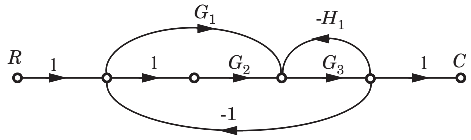


Fig. S6.1.32

$$T(s) = \frac{G_2G_3 + G_1G_3}{1 + G_3H_1 + G_2G_3}$$

33. (D) $P_1 = G_1G_3G_4$, $P_2 = G_2G_3G_4$, $P_3 = G_2G_4$

$L_1 = -G_1G_3G_4H_1H_2H_3$, $L_2 = -G_3G_4H_1H_2$, $L_3 = -G_4H_1$

There are no non touching loop

$\Delta_1 = \Delta_2 = \Delta_3 = 1$

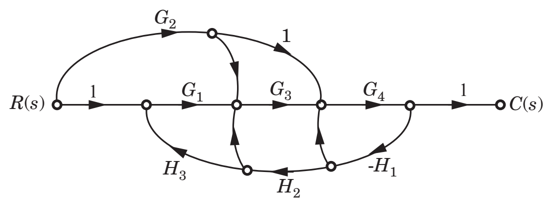


Fig. S6.1.33

$$T(s) = \frac{G_1G_3G_4 + G_2G_3G_4 + G_2G_4}{1 + G_1G_3G_4H_1H_2H_3 + G_3G_4H_1H_2 + G_4H_1}$$

34. (B) The SFG of this system is fig. S6.1.34

$L_1 = -G$, $L_2 = G$, $L_3 = G^2$, $L_1L_2 = -G^2$

$\Delta = 1 - (-G + G + G^2) - G^2 \ = 1 - 2\,G^2$

From R_1 to C_1, at $R_2 = 0$,

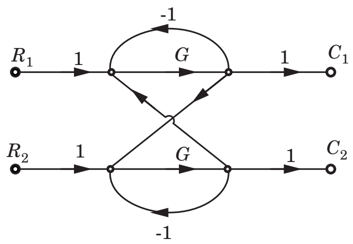


Fig. S6.1.34

$P_1 = G,$

$\Delta_1 = 1 - (G) = 1 - G$

$$\left.\frac{C_1}{R_1}\right|_{R_2=0} = \frac{G(1-G)}{1-2G^2}$$

35. (C) From R_2 to C_1 at $R_1 = 0$,

$P_1 = G^2$, $\Delta_1 = 1$,

$$\left.\frac{C_1}{R_2}\right|_{R_1=0} = \frac{G^2}{\Delta}$$

36. (B) From R_1 to C_2 ,

$P_1 = G^2$, $\Delta_1 = 1$,

$$\left.\frac{C_2}{R_1}\right|_{R_2=0} = \frac{G^2}{\Delta}$$

37. (A) From R_2 to C_1 at $R_1 = 0$,

$P_1 = G$, $\Delta_1 = 1 - (-G) = 1 + G$

$$\left.\frac{C_2}{R_2}\right|_{R_1=0} = \frac{G(1+G)}{\Delta}$$

38. (C) From Y_1 to Y_2 , $P_1 = 1$

$\Delta = 1 - (-G_1H_1 - G_2H_2 - G_3G_4H_3 + G_4H_1H_2 - G_1G_2G_3H_3)$

$\Rightarrow \Delta = 1 + G_1H_1 + G_2H_2 + G_3G_4H_3 + G_1G_2G_3H_3 - G_4H_1H_2$

$\Delta_1 = 1 + G_2\ H_2$, $\dfrac{Y_2}{Y_1} = \dfrac{P_1\ \Delta_1}{\Delta} = \dfrac{1 + G_2\ H_2}{\Delta}$

39. (D) From Y_1 to Y_5 , $P_1 = G_1G_2G_3$, $P_2 = G_4G_3$

$\Delta_1 = \Delta_2 = 1$, $\dfrac{Y_5}{Y_1} = \dfrac{G_1G_2G_3 + G_4G_3}{\Delta}$

$$\frac{Y_5}{Y_2} = \frac{\frac{Y_5}{Y_1}}{\frac{Y_2}{Y_1}} = \frac{G_1G_2G_3 + G_4G_3}{1 + G_2H_2}$$

40. (C) Consider block diagram as SFG

$P_1 = \dfrac{1}{s} \cdot 2s = 2$, $P_2 = 2 \cdot 2s = 4s$

$L_1 = \dfrac{1}{s}(-5) = \dfrac{-5}{s}$

$L_2 = \dfrac{1}{s} \cdot 2s \cdot (-1) = -2$

$L_3 = 2 \cdot 2s \cdot (-1) = -4s$

$L_4 = 2 \cdot (-5) = -10$

There are no nontouching loop

$\Delta = 1 - \left(-\dfrac{5}{s} - 4s - 2 - 10\right) = 13 + 4s + \dfrac{5}{s}$,

$\Delta_1 = \Delta_2 = 1,$

$$T(s) = \frac{2 + 4s}{13 + 4s + \frac{5}{s}} = \frac{2s(2s+1)}{4s^2 + 13s + 5}$$

41. (C) $T(s) = \dfrac{2s(2s+1)}{6s^2 + 13s + 5} = \dfrac{2s(2s+1)}{(s+0.5)(s+1.67)}$

So poles are –0.5, –1.67.

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